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# Cost-Effective Operation and Maintenance Six Cities Save over One Million Dollars

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Protecting Our Investment

EPA

# Cost-Effective Operation and Maintenance

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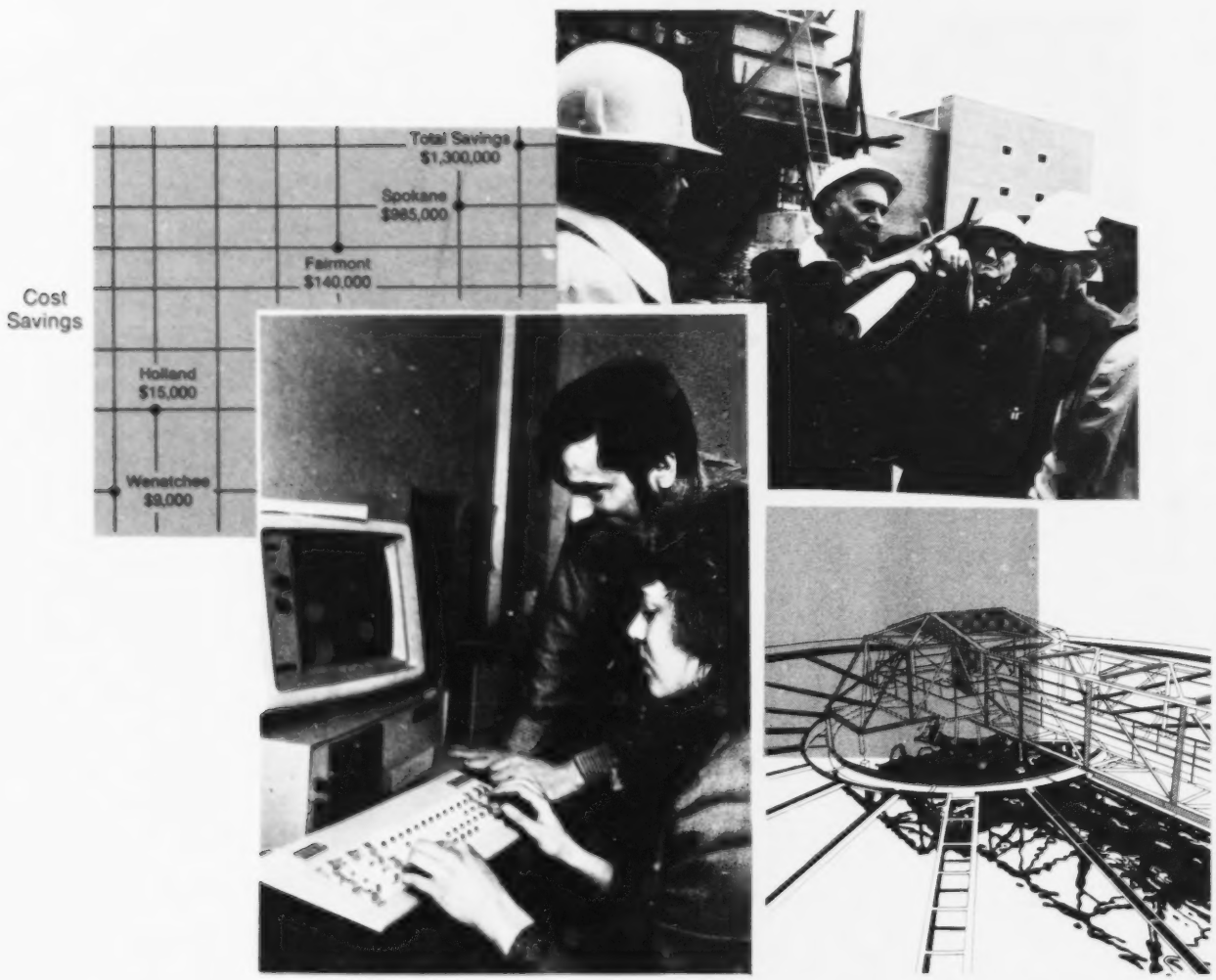


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# WHY YOU SHOULD CARE ABOUT EFFECTIVE WASTEWATER MANAGEMENT

Everyone has a stake in well managed sewage treatment and disposal, whether you are involved in it every day or consider it only when it is time to open the water and sewer bill. It is truly a universal concern: one vital to our health and quality of life. Yet, many plants across the country are not performing up to standards. Unfortunately, many are being operated, managed, and maintained in ways that are costly, inefficient, and short-sighted.

This situation is a concern for local citizens, who paid a great deal for construction and continue to pay utility service charges. Public officials also view inadequate performance with alarm, not knowing how to improve conditions without raising user charges. Poor performance is a sign of a good investment gone bad. The nation at large loses, too, because improved water quality in our rivers, lakes, and bays was the original intent behind Federal funding of sewage treatment plants. EPA is devoting much more effort to assisting communities with operation and maintenance issues.

Any public official concerned with wastewater treatment knows that treatment performance is being scrutinized more and more closely by an ever watchful public. Like many others, your office may be struggling with issues like high costs, under skilled staff, borderline effluent compliance, public dissatisfaction, sluggish information flow, and temperamental high technology treatment systems. Across America, people like you have struggled with those same problems, and won. Some of their approaches may work for you.

## Top Performing Plants Offer Tips On Management, Operation, and Maintenance

Concerned about the major public investment in treatment facilities, EPA decided to discover which positive approaches make wastewater management work. From a number of the best run plants in the nation, EPA selected the most representative for intensive study. These plants reflect the vast diversity of American wastewater treatment facilities in geographic location, size, flow, treatment level, and technology. Researchers looked for effective management approaches and operation and maintenance techniques that saved time and resources. They questioned plant managers about how these ideas worked, how much money they saved, and how they affected the treatment process.

Some of the ideas tried by plant superintendents and operators may work at your plant, and help you work toward a more efficient, better performing plant. You can:

- Improve plant performance and compliance,
- Safeguard the design life and good condition of your facility, and
- Hold the line on user charges that are affordable.

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16. ABSTRACT

This brochure offers cost-effective techniques on Operation and maintenance of a waste water treatment plant.

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# THE THREE KEYS TO SUCCESS

The good ideas suggested by your peers fell almost exclusively into three categories — the keys to successful wastewater treatment facility performance:

- Good Management
- Thrifty, Skillful Operations
- Effective Maintenance.

These three keys provide the framework for what follows. Each key is described, and some related techniques are presented. The section then goes on to relate several real life examples revealing how these cost-effective techniques were used by top performing plants. Of course, this short pamphlet can be neither detailed nor comprehensive. If you want more information or seek guidance on putting some of these techniques in place, further information is given in the back of the brochure.

Before we explore these three key issues in depth, however, it is important that a brief once-over be given of the basic management ingredients that must be in place if any plant is to operate well.

## The Basics Must Be In Place First

It's a fact. Unless your plant has the elements of good management, staffing, and budgeting, you won't be able to take advantage of these techniques for improving efficiency and performance. No team can win without a good coach, and no treatment plant can perform without a superintendent who is committed to top notch performance from his plant and staff. It is of critical importance that the manager know the basics of the treatment process, understand the elements of man agement, and be willing to experiment with new ideas and learn from those trials that succeed. It is also vital that the superintendent communicates freely with city management, including its financial decision makers.

It is equally true, however, that a top coach will never win the big ones without the best players. Your people are your most important resource. It is critically important that you recruit aggressively and pay well. Make sure you get the best and that you keep them. A well paid staff can more than cover higher labor costs by improved productivity and plant performance. Hold the staff to high standards, make them proud of their performance, show them that treatment plant operation is a highly technical profession and a vocation with a future. You will be rewarded by dedication to work and a staff that strives for the same high level of performance that you seek.

At the same time, insist on realistic financing for the plant. Most plants have experienced problems because budgeting focused on the short-term bottom line. Recognize that your maintenance budget is as important as operations. Deferred maintenance for the sake of temporary savings will cost more in the long run. For long-term maintenance and replacement of major capital items, you should establish a sinking fund. Insist on this type of budgeting, and in five years your plant will be shining with well functioning equipment, the rate payers will be satisfied, and applicable Federal and state permit requirements will be met.

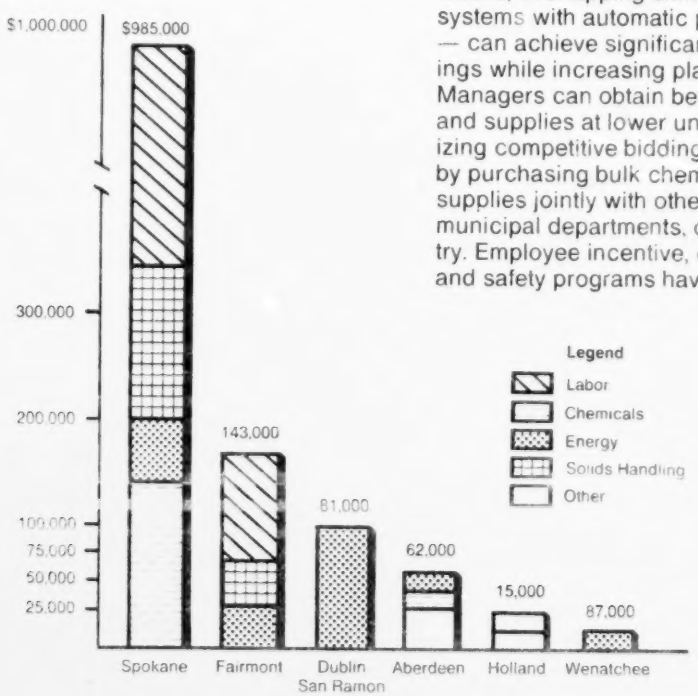
# GOOD MANAGEMENT PAYS OFF

What management techniques did the surveyed plants use most and declare most cost-effective? Staffing and scheduling innovations, purchasing efficiencies, and employee incentive and safety programs headed up the list. Others are shown in the box to the right. Actual examples of how management approaches have increased the cost-effectiveness of wastewater treatment plant operation and maintenance are discussed in the next section.

Staffing and scheduling changes — including the use of compressed work weeks, overlapping shifts, and alarm systems with automatic phone dialers — can achieve significant labor savings while increasing plant productivity. Managers can obtain better equipment and supplies at lower unit costs by utilizing competitive bidding practices and by purchasing bulk chemicals and supplies jointly with other communities, municipal departments, or local industry. Employee incentive, certification, and safety programs have resulted in safer, more efficient operations, improved staff morale, significant reductions in overtime and accident pay, and better trained operators.

**Proven Effective: Management Techniques That Work**

- *Staffing and scheduling innovations*
- *Purchasing efficiencies (e.g., bulk chemicals, competitive bids)*
- *Employee training, certification, and incentive programs*
- "Cross-training" staff: encouraging general capabilities rather than specialists
- Sharing administrative functions (and costs) with other departments
- Providing contract services like lab work and disposal of grease and sludge for smaller plants
- Implementing computerized management and information systems




Selected Cost Reduction Measures at 6 Wastewater Facilities; Facilities Used Additional Cost Saving Methods Beyond Those Included Here.

# SUCCESS STORIES: GOOD MANAGEMENT

## Schedule Changes Save Costs By Trimming Staff

The Spokane, Washington wastewater treatment facility — a 44 mgd advanced wastewater treatment plant — reduced its staffing needs by 18% through a variety of changes in staff scheduling. The reduction from 90 to 74 staff over the last six years has resulted in labor cost savings of more than $600,000 per year, while increasing plant productivity. Staff reduction was made possible by changing to a ten-hour day, four-day work week with permanent shifts. In addition, the wages of grade III operators were increased. The staff was pleased with these changes and responded with an increase in productivity. Other productivity increases were achieved by assigning a support crew to work with each of the day shift operations crews and by development of a new operations and maintenance manual by the plant staff themselves. As an indication of the positive effect on staff morale, the plant has not lost an operator in over three years. In contrast, personnel turnover prior to the utilization of cost-effective techniques was 100% every six months.

The Aberdeen, Maryland treatment facility, a small (4 mgd) advanced wastewater treatment plant, also utilized staffing and scheduling changes to achieve cost savings. Staffing reductions were partially accomplished by a change to a four-day work week, with ten-hour overlapping shifts. This eliminated the need for two permanent staff positions, with the shift overlap also eliminating the need for overtime work. With this strategy, effluent quality was maintained with fewer staff. At the same time, staff morale has increased and turnover has significantly decreased. Plant staff at this 4 mgd plant were also cross-trained and staff responsibilities restructured so that absences and vacancies could be easily accommodated.

The Fairmont, West Virginia treatment plant is a 6 mgd secondary plant using rotating biological contactors. It went on line in 1984. Fairmont uses overtime as a means to cover weekend and holiday O&M needs. Although overtime is considered a high cost item at many plants, management in Fairmont performed an analysis of staffing and overtime use and determined that by incurring overtime costs equivalent to one staff salary, they could avoid the need to hire two extra staff members. Specifically, over the past year, overtime pay of $22,000 was incurred. Two new hires would have cost approximately $46,000 per year.

This same plant also installed an autodial alarm system that eliminated the need for a third shift during the week plus a second shift on weekends. The autodial system resulted in a reduction of staff needs that represents an estimated $50,000 savings per year in labor costs with only a limited capital investment. This savings was accomplished while removal efficiencies increased.

An autodial alarm system was also installed at the Wenatchee, Washington treatment plant. Wenatchee is a 5 mgd secondary, activated sludge plant. The plant is only staffed eight hours each day, seven days a week. The shifts are

arranged so that peak staffing is in place when maximum plant flows occur. During periods when the plant is not staffed, the alarm system with the autodialer is in place to summon help if there are any operating incidents. This arrangement has required only 17 hours of overtime over the period of one year to respond to plant alarms. With these staffing and operations procedures in place, the plant can be staffed with only nine persons. The design engineer's estimate of staff required to operate the plant was 14. An indication of the success of these management practices is that effluent quality has consistently been better than permit limits.

An employee incentive program, which makes monetary awards for superior performance and suggestions for more efficient plant operations, has proved to be a significant morale booster at the Spokane plant. In addition to increasing productivity, one employee recently received a $1,200 bonus for suggestions that saved $17,000 in operating costs per year.

## Use Training And Employee Incentives To Increase Productivity

The Dublin San Ramon, California treatment facility is a 9 mgd secondary, activated sludge treatment plant. An aggressive safety program has been implemented at this plant that has resulted in extremely safe operations. This program provides for: chlorine training seminars, which are open to area fire and rescue squads in addition to plant personnel; the creation of a plant safety committee; and the use of hazardous conditions reports. The successful integration and use of these actions have resulted in no loss-of-time accidents in the past year.

An employee incentive program for low sick leave and workers compensation usage has increased productivity and morale and reduced overtime costs at the Fairmont plant. This program provides bonuses to employees if they do not use all their sick leave, based on a prorated, sliding scale. The plant's self-insured workers compensation program allows it to provide bonuses to workers from the interest earned on the fund principal if all compensation is not paid out. Incentive pay for higher licensing, on the order of $.50 per hour per level (up to $1.50 per hour), has also resulted in improved staff morale, as well as providing for better trained operators.

# OPERATIONS: THE FULCRUM FOR LEVERAGING COST-EFFECTIVENESS

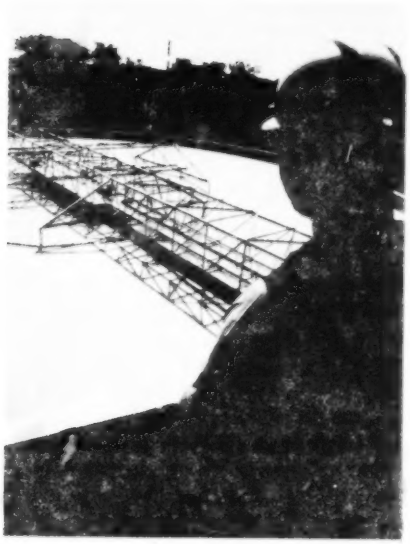
## Modify Purchasing To Buy More Performance For Less

In Spokane, a number of techniques are utilized for efficient and cost-effective purchasing of supplies. These techniques include joint purchasing, coordinated bulk purchases of chemicals with surrounding municipalities and private industries, prequalification of suppliers, and competitive bidding practices. For example, the plant cooperates with the local paper mill in the timing of bids for alum, and coordinates the purchasing of all housekeeping supplies, and office and automotive equipment with other city departments. The plant also buys chemicals in bulk for surrounding, smaller communities. Prequalification of suppliers and competitive bidding practices have resulted in savings of $100,000 by purchasing less expensive, better performing equipment and supplies.

To ensure cost-effective chemical purchases, staff at the Aberdeen plant make purchasing decisions on the basis of yearly tests of chemical performance, not just low unit costs. This allows for chemicals to be purchased not only at lower rates, but at costs based on the removal efficiency of chemicals.

Plant operations involve a wide range of chemical and biological processes used in treatment, as well as the electrical and mechanical equipment associated with them. Because of the number of processes involved and the extensive use of electrical and mechanical equipment, efficiencies can be maximized at many points. Indeed, strategies for increasing cost-effectiveness have traditionally focused on plant operations.

Operational efficiencies can result in a plant that runs more economically, performs at higher output levels, and requires less labor. Most of the techniques recommended by the plants studied fall into one of two categories: those that save chemicals and those that save energy. The box on the next page identifies specific ideas.



Several other approaches are both widely used and very effective:

- *Optimizing Unit Processes* — Taking unneeded process units off-line, if planned wisely, can boost the efficiency of remaining units, save energy, and conserve equipment.
- *Equalizing Flow* — Flow equalization helps achieve maximum efficiency by running a nearly constant flow through the plant. It saves money by allowing a significant amount of flow to be treated during off-peak electrical hours.
- *Modifying Solids Processes* — Dewatering and disposal of sludge are the major sources of solids handling costs. Major savings can be achieved by altering the overall solids processes to minimize dewatering and by changing from expensive disposal techniques like incineration or landfilling to less expensive methods such as land application.

The following section provides actual success stories from the high performance plants studied. Fine-tuning operations has definitely paid off for them.

**Modifying Operations Can Save Energy and Chemicals**

Successful plant managers save energy by:

- Recovering and using digester gas
- Using energy management to minimize peak period use and keep power factors low
- Maximizing process efficiency
- Using automated process controls or timers to streamline use of electrical equipment
- Using only the minimum level of aeration needed to maintain biological processes and meet effluent limits
- Reducing interior and exterior lighting

High performance plants save chemicals and boost treatment efficiency by:

- Substituting alternative chemicals
- Using waste byproducts in lieu of expensive chemicals
- Fine-tuning chemical feed to identify point of maximum efficiency
- Using automated process controls to maintain optimal level of chemical feed
- Maximizing performance of biological processes to lower chemical use for nutrient removal

# SUCCESS STORIES: THRIFTY, SKILLFUL OPERATIONS

## Fewer Unit Processes Equals High Quality Effluent With Less Cost

Many of the treatment plants in the study have improved cost-efficiency by taking certain units off-line. Some did so to cut use of unneeded equipment, others did so to equalize flows and maximize efficiency of remaining process units. Over $8,000 per year was saved at the Wenatchee, Washington plant by taking one flotation thickener, an aeration basin, and a secondary clarifier off-line. Taking equipment off-line is entirely dependent upon individual plant designs, flows, and permit limits. It will clearly be more feasible at plants where flows are well below design flow. Taking units off-line should never be done where adverse effects on effluent quality could result. All of the plants in the survey maintained or improved effluent quality even with units off-line.

## Equalize Flows To Use Off-Peak Electricity

Use of off-line units or dedicated storage facilities to equalize flow through the plant has also been used at many treatment facilities. The Dublin San Ramon plant has primary effluent basins which are used for storage, decreasing peak pumping rates, and maximizing electrical usage during off-peak periods. Cost savings were estimated to be $21,000 per year. At the Florence, South Carolina plant (a 10 mgd trickling filter system), it was estimated that equalization has resulted in a yearly electrical savings of $24,000 per year.

## Revised Solids Handling Effects Major Savings

Cost-effective handling of solids has been accomplished at a number of plants in the study. In Spokane, solids handling costs were cut $200,000 by replacing vacuum filters with belt presses, switching from lime and ferric chloride to polymers only, and applying dewatered sludge to farmland instead of disposing of it in a landfill. A smaller plant in the same region has been able

to cut costs by an even greater rate by eliminating dewatering and applying liquid sludge to city owned land at the airport. The Fairmont, West Virginia plant is saving over $40,000 per year in landfill costs alone by using land application.

## Use In-Plant Energy To Replace Costly Electricity

Recovery of digester gas as a power and heat source is another cost-effective technique that is being employed more frequently at plants around the country. Many plants have been designed with anaerobic digesters and methane recovery systems; however, many were not utilized or performed poorly. Rehabilitation or improving the performance of existing systems will usually be cost-effective. Construction of a new system should be carefully evaluated. An eastern 4 mgd advanced wastewater treatment facility was able to save $10,000 per year in fuel oil by reactivating methane recovery.The Fairmont, West Virginia plant recovers methane equal to $30,000 in fuel oil costs each year. Use of methane to generate electricity (cogeneration) is also feasible, but probably not cost-effective on a retrofit basis. Cogeneration has supplied over $60,000 (in net value) per year in electricity to the Dublin San Ramon plant. It should be pointed out, however, that cogeneration equipment can be very costly. Cogeneration equipment may only be cost-effective where electrical rates are very high or where a portion of the capital cost can be recovered.

Other energy savings include an estimated savings of $45,000 in electricity at Spokane by limiting the speed and submergence of mechanical aerators to maintain only the minimum level of dissolved oxygen necessary (.5mg/l). Plant effluent quality is still as high or better than before this technique was implemented.

Electrical savings do not have to come from sophisticated operating techniques. The Wenatchee plant saved over $500 per year just by taking out unneeded light bulbs. Other plants have saved even greater amounts just from eliminating extra lighting.

## Save Costs With Attention To Chemical Use

The Aberdeen Plant has implemented two techniques to save money in the use of chemicals. By reworking the lime feed system to meter only the minimum necessary dosage, $14,000 per year has been saved. Substantial savings have also been achieved by replacing alum with aluminum chloride, which is a waste byproduct of the chemical industry and can be purchased for transportation costs only.

Chemical savings are possible at large plants as well as small. Spokane has been able to save $40,000 per year by reducing lime dosage by about a third without upsetting the treatment process. Better monitoring of chemical usage was achieved by transferring supplies from bulk storage to individual tanks holding one day's chemical requirements. These types of actions rarely have a substantial capital cost, and often can be carried out by the plant operations or maintenance personnel.

# EFFECTIVE MAINTENANCE KEEPS PERFORMANCE HIGH

Today's complex POTWs require a highly skilled maintenance staff with excellent mechanical, analytical, observational, and troubleshooting talents. Such personnel are costly, but in the long run, inadequate plant O&M is costlier still. The management section of this brochure provides some innovative ideas for getting good staff economically and using them strategically. The ideas presented here cover other aspects of maintenance.

Modified or improved maintenance activities can reduce costs by cutting consumption of electricity, water, and lubricants. Skillful maintenance also increases the reliability of equipment, resulting in lower labor costs. Overall benefits generally include less down time for equipment and more predictable expenditures for maintenance. Maintenance practices most highly recommended by the plants studied are shown in the box on the right.

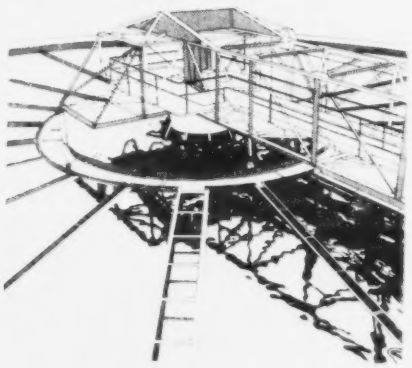
Maintenance cost reduction can also be pursued on an even larger scale. However, such techniques require special care or expertise to be successfully implemented. For example, the plant's O&M manual can be assessed for procedures that can be changed, but experience with plant requirements is crucial to assure that proper operations will continue. Instituting a capitalization program (the process whereby funds are set aside regularly for long-term needs) for major repairs and replacement can reduce nonbudgeted emergency expenditures. However, such a program cannot be implemented without expertise in accounting and finance. Elimination of collection system infiltration and inflow will generally lead to reduced energy and chemical costs and improved operation, but the expense of such an effort requires a careful analysis of cost-effectiveness before proceeding.

The following section offers maintenance success stories from 15 well run plants across the country.

**Preserve Gains With Good Maintenance Practices**

- Enforce scheduled preventive maintenance, organized by a card file or computer program
- Increase plant staff capability to handle routine and nonroutine maintenance instead of relying on service contracts
- Institute an oil analysis program to optimize frequency of oil changes
- Develop a cross-referenced parts listing to reduce the number of parts that must be kept inventoried and to increase ability to obtain parts competitively
- Rebuild equipment to save on operating and replacement costs
- Invest in equipment that will need less maintenance or prolong the life of existing equipment (e.g., radial tires on trucks and mechanical seals on centrifugal pumps)

# SUCCESS STORIES: EFFECTIVE MAINTENANCE



## Preventive Maintenance Can Help Any Plant

Card-based preventive maintenance systems have been available for a long time and can be effective in directing a preventive maintenance program. More recently, computer-based systems have been developed that can automatically generate maintenance schedules, work orders, and backlogs, and have the potential to improve maintenance capability at any plant that implements such a system. Additionally, some systems exist which will generate an inventory of spare parts needed.

For example, both the Spokane and Fairmont plants successfully use card-based preventive maintenance systems, citing benefits of minimal unplanned down time and low levels of overtime for maintenance. At Spokane, there are now plans to install a computerized system. In Fairmont, a planned computer process control system including preventive maintenance is now being put in place.

The Holland, Michigan treatment facility, an 8.5 mgd oxygen-activated sludge plant, has found that its computerized preventive maintenance system provides a more precise allocation of maintenance time and is expected to result in increased equipment reliability. Staff at the Dublin San Ramon plant also have found the computerized preventive maintenance program beneficial in maximizing equipment life and minimizing breakdowns and maintenance overtime.

## In-House Repair Capability Has Many Benefits

Service contracts costing $38,000 annually have been eliminated at the Aberdeen plant by training plant staff to handle nearly all maintenance tasks. This in-house capability also allows faster response to problems, but has required some investment in training to obtain necessary skills. In Holland, Michigan, the plant staff repaired pump seals throughout the facility, resulting in a 20% savings in water. Staff in Holland also rebuilt lime slakers in-house for half the cost of replacing them. A 3 mgd activated sludge plant in Weirton, West Virginia found it saved 10-15% on the cost of operating a sludge pump by rebuilding it, while in Wenatchee, an aging lift station was rebuilt resulting in a large reduction in maintenance overtime.

## WHERE TO GO FROM HERE

### Lubricants And Spare Parts: Expensive Necessities

The expense of maintaining a spare parts inventory can be controlled in several ways. The plant in Spokane, Washington and a 700,000 gpd activated sludge plant in Burrillville, Rhode Island both have developed cross-referenced spare parts lists to allow for purchasing off-the-shelf from local suppliers instead of maintaining extensive and expensive inventories. Such cross-referencing also is used as a basis for competitive purchasing instead of buying by brand name.

A 5 mgd activated sludge plant in Amherst, Massachusetts has instituted an oil analysis program to reduce the frequency of oil changes. This program indicated that synthetic oil was the most cost-effective lubricant. The same oil has been in place for three years, avoiding the labor associated with normal twice-yearly oil changes.

An 886,000 gpd activated sludge plant in River Falls, Wisconsin found one grease that would serve all plant needs, which simplified its maintenance procedures and reduced purchasing costs and inventory. While this is an option available to you, it is important that lubricants be used that are in accordance with equipment manufacturer's specifications.

Not all of the techniques described here will apply to your treatment plant. As the success stories reveal, some are more appropriate for small plants, others for large plants; some for conventional secondary treatment facilities, others for advanced wastewater treatment facilities. Obviously, it is more difficult to pursue chemical cost savings in secondary treatment plants. Before you begin to implement techniques, you should carry out an assessment of your plant.

Begin by evaluating the adequacy of overall plant management. Are operations and administration well organized? Do information systems alert managers to problems, and does problem resolution feed back into planning? Are personnel and financial management systems sound? Is reporting scrupulous, and does it drive maintenance procedures and fine tune operations?

If the basics are in place, go to the next level of detail. Are you operating at optimum staffing levels? Staffing guidelines are available in many reference sources. However, we suggest you talk to superintendents at other well run plants. In many cases, you can run a plant well with fewer staff than the guidelines recommend. Examine training, other staff skill-building activities, and performance incentives. Are they effective? What about purchasing procedures? Are you getting the most for your dollar?

Assessing your own procedures and determining their costs will give you a baseline for comparing your operations to those of other plants. Where you see room for improvement, you may want to consider the techniques suggested in this pamphlet as well as others to be found in the references listed below. Careful assessment will reveal which of the recommended techniques are right for your situation.

Managers who are willing to undertake the task of self scrutiny are well on the road to better management, operations, and maintenance of their community's wastewater facility.

# SOURCES

More information on the cost-effective techniques discussed in this brochure is available from EPA's Office of Municipal Pollution Control, 401 M Street, S.W., Washington, D.C., 20460 (202) 382-5998.

The following reference sources are also suggested:

- "Energy Conservation for Existing Wastewater Treatment Plants," *Journal of the Water Pollution Control Federation,* Volume 53, Number 5, Bruce E. Burris, 1981.
- *Technical Report, Operation and Maintenance Costs for Municipal Wastewater Facilities,* U. S. EPA, 1981.
- "Cost Reduction and Self-Help Handbook," U.S. EPA, 1986.
- *Energy Conservation at Wastewater Treatment Plants,* Water Pollution Control Federation, 1980.
- *Plant Maintenance Program,* Manual of Practice OM-3, Water Pollution Control Federation, 1982.

This brochure was prepared by EPA's Office of Municipal Pollution Control, Planning and Analysis Division. We wish to recognize the assistance of the treatment plant staff of the following municipalities: Aberdeen, Maryland; Fairmont, West Virginia; Dublin San Ramon Services District, California; Holland, Michigan; Spokane, Washington; and Wenatchee, Washington. The staff at the following plants around the country also gave time for phone interviews: East Providence, Rhode Island; Pocatello, Idaho; Burrillville, Rhode Island; Weirton, West Virginia; Amherst, Massachusetts; Lake of Egypt, Illinois; Clarksdale, Mississippi; River Falls, Wisconsin; and Florence, South Carolina. EPA was assisted in the preparation of the brochure by the staff of Roy F. Weston, Inc., and Peat, Marwick, Mitchell and Company.